

CONFIDENTIAL

916-24

Important Safety Precautions

Read and observe these safety precautions when using or working on electric generators, engines and related equipment. Also read and follow the literature provided with the equipment.

Proper operation and maintenance are critical to performance and safety. Electricity, fuel, exhaust, moving parts and batteries present hazards that can cause severe personal injury or death.

FUEL, ENGINE OIL, AND FUMES ARE FLAMMABLE AND TOXIC

Fire, explosion, and personal injury can result from improper practices.

- Used engine oil, and benzene and lead, found in some gasoline, have been identified by government agencies as causing cancer or reproductive toxicity. When checking, draining or adding fuel or oil, do not ingest, breathe the fumes, or contact gasoline or used oil.
- Do not fill tanks with engine running. Do not smoke around the area. Wipe up oil or fuel spills. Do not leave rags in engine compartment or on equipment. Keep this and surrounding area clean.
- Inspect fuel system before each operation and periodically while running.
- Equip fuel supply with a positive fuel shutoff.
- Do not store or transport equipment with fuel in tank.
- Keep an ABC-rated fire extinguisher available near equipment and adjacent areas for use on all types of fires except alcohol.
- Unless provided with equipment or noted otherwise in installation manual, fuel lines must be copper or steel, secured, free of leaks and separated or shielded from electrical wiring.
- Use approved, non-conductive flexible fuel hose for fuel connections. Do not use copper tubing as a flexible connection. It will work-harden and break.

EXHAUST GAS IS DEADLY

- Engine exhaust contains carbon monoxide (CO), an odorless, invisible, poisonous gas. Learn the symptoms of CO poisoning.
- Never sleep in a vessel, vehicle, or room with a genset or engine running unless the area is equipped with an operating CO detector with an audible alarm.
- Each time the engine or genset is started, or at least every day, thoroughly inspect the exhaust system. Shut down the unit and repair leaks immediately.

- Warning: Engine exhaust is known to the State of California to cause cancer, birth defects and other reproductive harm.

Make sure exhaust is properly ventilated.

- Vessel bilge must have an operating power exhaust.
- Vehicle exhaust system must extend beyond vehicle perimeter and not near windows, doors or vents.
- Do not use engine or genset cooling air to heat an area.
- Do not operate engine/genset in enclosed area without ample fresh air ventilation.
- Expel exhaust away from enclosed, sheltered, or occupied areas.
- Make sure exhaust system components are securely fastened and not warped.

MOVING PARTS CAN CAUSE SEVERE PERSONAL INJURY OR DEATH

- Do not remove any guards or covers with the equipment running.
- Keep hands, clothing, hair, and jewelry away from moving parts.
- Before performing any maintenance, disconnect battery (negative [-] cable first) to prevent accidental starting.
- Make sure fasteners and joints are secure. Tighten supports and clamps, keep guards in position over fans, drive belts, etc.
- If adjustments must be made while equipment is running, use extreme caution around hot manifolds and moving parts, etc. Wear safety glasses and protective clothing.

BATTERY GAS IS EXPLOSIVE

- Wear safety glasses and do not smoke while servicing batteries.
- Always disconnect battery negative (-) lead first and reconnect it last. Make sure you connect battery correctly. A direct short across battery terminals can cause an explosion. Do not smoke while servicing batteries. Hydrogen gas given off during charging is explosive.
- Do not disconnect or connect battery cables if fuel vapors are present. Ventilate the area thoroughly.

DO NOT OPERATE IN FLAMMABLE AND EXPLOSIVE ENVIRONMENTS

Flammable vapor can be ignited by equipment operation or cause a diesel engine to overspeed and become difficult to stop, resulting in possible fire, explosion, severe personal injury and death. **Do not operate diesel equipment where a flammable vapor environment can be created by fuel spill, leak, etc., unless equipped with an automatic safety device to block the air intake and stop the engine.**

HOT COOLANT CAN CAUSE SEVERE PERSONAL INJURY

- Hot coolant is under pressure. Do not loosen the coolant pressure cap while the engine is hot. Let the engine cool before opening the pressure cap.

ELECTRICAL SHOCK CAN CAUSE SEVERE PERSONAL INJURY OR DEATH

- Do not service control panel or engine with unit running. High voltages are present. Work that must be done while unit is running should be done only by qualified service personnel.
- Do not connect the generator set to the public utility or to any other electrical power system. Electrocution can occur at a remote site where line or equipment repairs are being made. An approved transfer switch must be used if more than one power source is connected.
- Disconnect starting battery (negative [-] cable first) before removing protective shields or touching electrical equipment. Use insulative mats placed on dry wood platforms. Do not wear jewelry, damp clothing or allow skin surface to be damp when handling electrical equipment.
- Use insulated tools. Do not tamper with interlocks.
- Follow all applicable state and local electrical codes. Have all electrical installations performed by a qualified licensed electrician. Tag open switches to avoid accidental closure.
- With transfer switches, keep cabinet closed and locked. Only authorized personnel should have cabinet or operational keys. Due to serious shock hazard from high voltages within cabinet, all service and adjustments must be performed by an electrician or authorized service representative.

If the cabinet must be opened for any reason:

1. Move genset operation switch or Stop/Auto/Handcrank switch (whichever applies) to Stop.
2. Disconnect genset batteries (negative [-] lead first).
3. Remove AC power to automatic transfer switch. If instructions require otherwise, use extreme caution due to shock hazard.

MEDIUM VOLTAGE GENERATOR SETS (601V TO 15kV)

- Medium voltage acts differently than low voltage. Special equipment and training are required to work on or around medium voltage equipment. Operation and maintenance must be done only by persons trained and qualified to work on such devices. Improper use or procedures will result in severe personal injury or death.
- Do not work on energized equipment. Unauthorized personnel must not be permitted near energized equipment. Induced voltage remains even after equipment is disconnected from the power source. Plan maintenance with authorized personnel so equipment can be de-energized and safely grounded.

GENERAL SAFETY PRECAUTIONS

- Do not work on equipment when mentally or physically fatigued or after consuming alcohol or drugs.
- Carefully follow all applicable local, state and federal codes.
- Never step on equipment (as when entering or leaving the engine compartment). It can stress and break unit components, possibly resulting in dangerous operating conditions from leaking fuel, leaking exhaust fumes, etc.
- Keep equipment and area clean. Oil, grease, dirt, or stowed gear can cause fire or damage equipment by restricting airflow.
- Equipment owners and operators are solely responsible for operating equipment safely. Contact your authorized Onan/Cummins dealer or distributor for more information.

KEEP THIS DOCUMENT NEAR EQUIPMENT FOR EASY REFERENCE.

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GENERAL INFORMATION

This instruction book contains information for the proper installation, operation, and maintenance of your equipment. We suggest that this book be kept handy so that it can be referred to when necessary.

This equipment is the result of proven engineering design, highest quality materials, and expert workmanship. Thorough inspection and testing assures you that this equipment will perform as expected.

If you wish to contact your dealer or the factory regarding this equipment, be sure to supply the complete MODEL and SPEC. NO., and the full serial number of the equipment as shown on the nameplate. This information is necessary to identify the equipment among the many basic and special optional types manufactured.

MANUFACTURER'S WARRANTY

The Manufacturer warrants each product of its manufacture to be free from defects in material and factory workmanship if properly installed, serviced and operated under normal conditions according to the Manufacturer's instructions.

Manufacturer's obligation under this warranty is limited to correcting without charge at its factory any part or parts thereof which shall be returned to its factory or one of its Authorized Service Stations, transportation charges prepaid, within ninety (90) days after being put into service by the original user, and which upon examination shall disclose to the Manufacturer's satisfaction to have been originally defective. Correction of such defects by repair to, or supplying of replacements for defective parts, shall constitute fulfillment of all obligations to original user.

This warranty shall not apply to any of the Manufacturer's products which must be replaced because of normal wear, which have been subject to misuse, negligence or accident or which shall have been repaired or altered outside of the Manufacturer's factory unless authorized by the Manufacturer.

Manufacturer shall not be liable for loss, damage or expense directly or indirectly from the use of its product or from any other cause. The Manufacturer makes no warranty whatsoever with respect to component parts which are warranted separately by their respective manufacturers.

The above warranty supersedes and is in lieu of all other warranties, expressed or implied, and no person, agent or dealer is authorized to give any warranties on behalf of the Manufacturer nor to assume for the Manufacturer any other liability in connection with any of its products unless made in writing and signed by an officer of the Manufacturer.

D. W. ONAN & SONS INC., MINNEAPOLIS 14, MINN.

IMPORTANT

RETURN WARRANTY CARD ATTACHED TO UNIT

These instructions apply to the ACK industrial engine manufactured by D. W. ONAN & SONS INC., Minneapolis 14, Minnesota. This 2-cylinder air-cooled gasoline engine meets Military Specifications MIL-E-11275B. Suppression meets Military Specification MIL-I-11683B.

ENGINE DESIGN DATA

Engine Model (Basic)	Onan ACK
Dimensions	See Drawing 100B188, herein
Type	2-cylinder, Horizontally opposed, air-cooled, L-head, 4-stroke cycle
Governor	Flyball Type, Externally Adjustable
Ignition	Magneto With Impulse
Air Cleaner	Dry Type
Oil Pump	Gear Type
Oil Pressure Control	Adjustable, Spring Loaded By-Pass
Oil Capacity	3 Quarts (U. S. Measure)
Pistons	3-ring, Aluminum Alloy
Valves	Stellite Face, Positive Type Rotators, 44° Face Angle
Cylinder Bore	3-inch
Stroke	2-3/4 inch
Compression Ratio	6.25 to 1
Piston Displacement	38.8 cubic inches
Connecting Rods	Forged, with Replaceable Bearings
Main Bearings	Precision Type, Flanged Sleeve Type
Cylinders - Crankcase	Cast Integral, Aluminum Alloy
Crankcase Ventilation	Breather Valve and Fume-vent
Fuel Pump	Diaphragm Type
Cranking Method	Manual Pull Rope
Dry Weight with Accessories	116 Lbs. Nominal

ENGINE PERFORMANCE DATA

Tilt Angle In All Directions.	200° maximum
Rotation (When facing power-take-off-shaft).	Counterclockwise
Rated Governed Speed.	3600 rpm
Maximum Brake Horsepower at 3600 rpm with accessories.	13.48
Net Continuous Brake Horsepower at 3600 rpm with accessories (Meets requirements in MIL-E-11275B, Group I).	8.5
Maximum Torque at 2000 rpm.	23.5 Ft. Lbs.
Fuel Consumption at Continuous Horsepower Rating.	0.884 lbs. /bhp./hr.

GENERAL. - Too much emphasis cannot be placed on the importance of properly installing the engine. The life of the engine, its economy of operation, and the less frequent need for repairs and adjustments are a few of the factors that are dependent on proper installation.

Provide the most suitable installation possible, according to the particular application in question. Make the installation with the following factors in mind.

1. Adequate ventilation, continuous supply of fresh air. (Inlet 3-1/2 sq. ft.)
2. Rigid base and securely mounted.
3. Proper alignment with load.
4. Accessible for cranking and servicing.
5. Exhaust gases piped to outside of enclosure using pipe as large or larger than engine outlet.
6. Flexible exhaust pipe near engine.
7. Condensation trap at upward pitch in exhaust line.
8. Exhaust pipe shielded from flammable material.
9. Protection from the elements for outdoor installations, where practicable.
10. Properly selected size of pulley or other drive to attain desired speed of load and most suitable engine speed for required output and operation economy.
11. Fuel lift from tank should be not more than 4 feet for dependable operation.
12. Flexible fuel line should be used near the engine.

INSTALLATION

CLUTCH INSTALLATION. - Certain applications may require a Rockford Clutch installed on the engine. These clutches can be installed at the factory or in the field.

Comply in the sequence given to install the clutch. See the illustration.

Provide room for the clutch adapter casting by discarding the air housing clip and the capscrew from the wet hole into the #2 valve compartment. Plug this hole with a $3/8-16 \times 1/2"$ slotted headless set screw and apply sealing compound until flush with the cylinder block.

Provide a $13/64"$ drilled hole (or filed slot) in the crankshaft for the clutch setscrew. Locate center of hole $11/32"$ from the end and directly opposite the keyway in the crankshaft.

Use a lockwasher on each assembly screw. Use a flat washer and a lockwasher under the stud nut.

Install the clutch adapter, with drain slot downward, to the engine, using two capscrews $3/8-16 \times 2"$ on the lower and one capscrew $3/8-16 \times 1-3/4"$ on the upper #2 cylinder side (cylinder nearer clutch). Install the $3/8-16 \times 3-7/8"$ stud through the adapter into the engine block upper remaining hole.

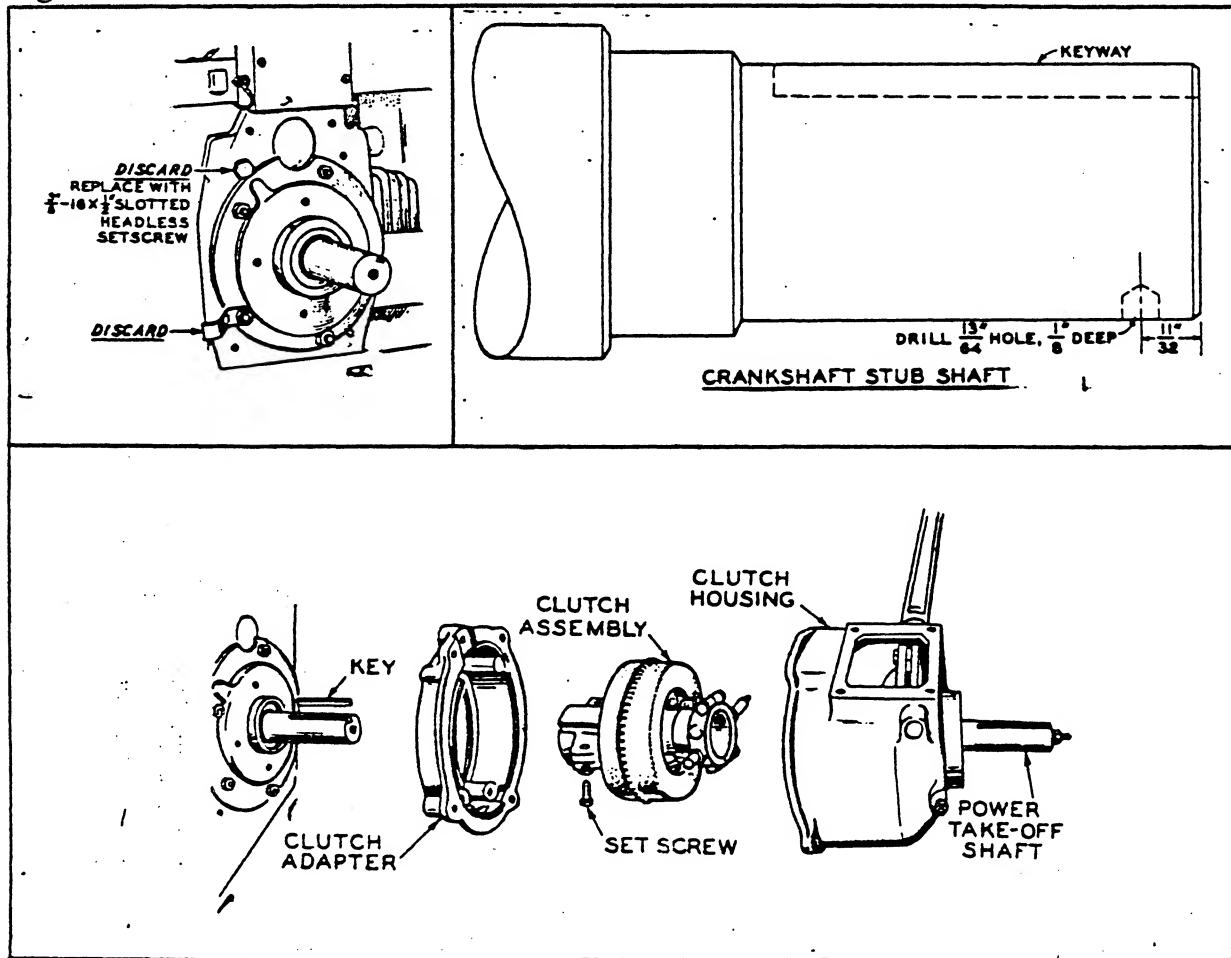


FIG. 2 - ROCKFORD CLUTCH INSTALLATION

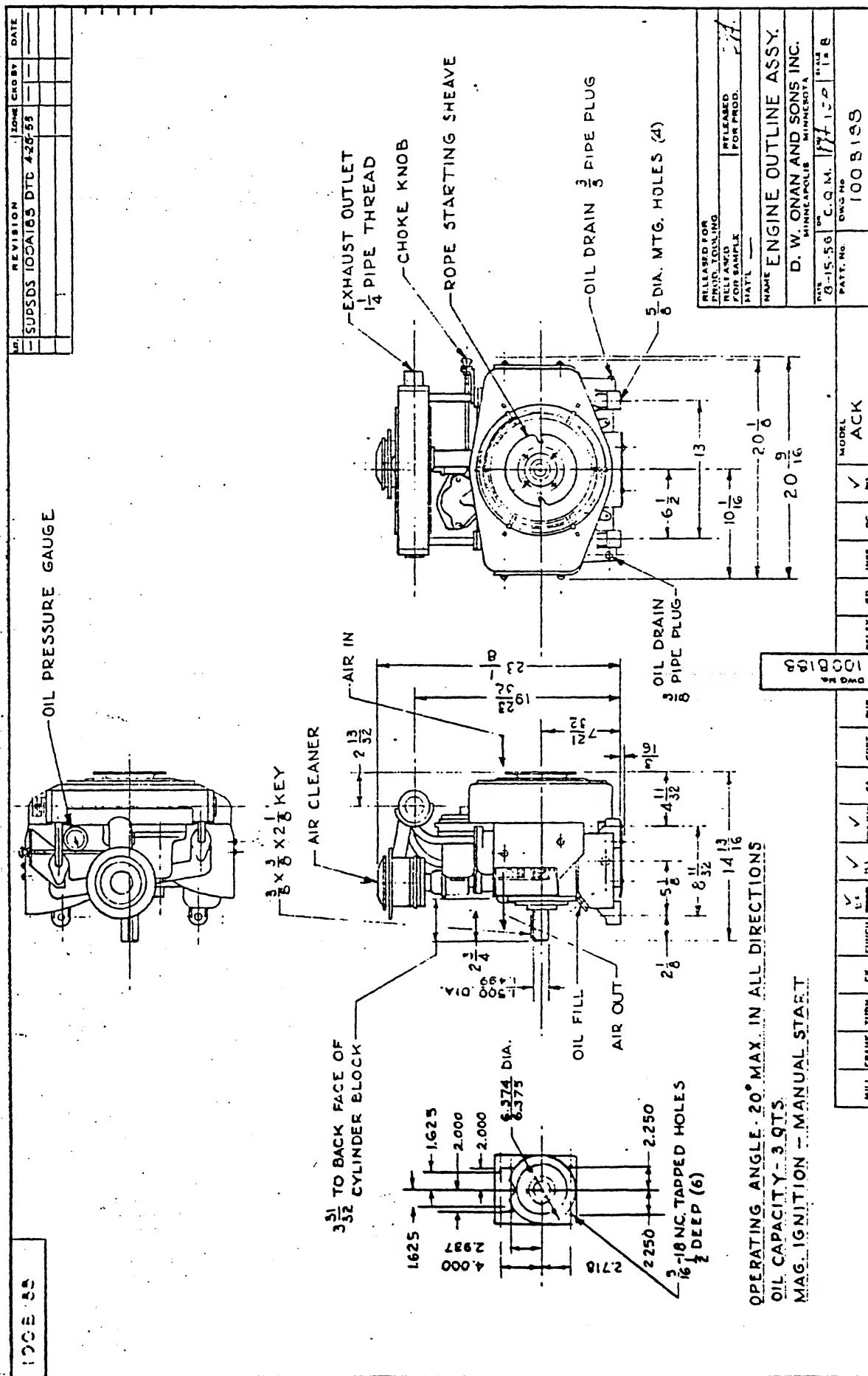


FIG. 1 - DIMENSIONAL OUTLINE

Before operating the engine, it must be properly serviced with oil and fuel. Serious damage can result from running the engine for just a minute or two without oil. If extreme ambient temperatures or abnormal operating conditions exist, refer to the separate section on Abnormal Operating Conditions.

CRANKCASE OIL. - The oil capacity of the engine is 3 quarts (U.S. Measure). The oil fill opening is on the left rear side of the oil base. A bayonet type oil level gauge is an integral part of the oil fill cap.

Use the correct grade of crankcase oil as indicated in the following table. The grade is determined by the lowest temperature to which the engine will be exposed when it is idle.

TEMPERATURE	OIL GRADE
Above 90°F.	OE 50, Spec. MIL-O-2104 (ORD)
32°F. to 90°F.	OE 30, Spec. MIL-O-2104 (ORD)
40°F. to -10°F.	OE 10, Spec. MIL-O-2104 (ORD)
0°F. to -65°F.	OE-S, Spec. MIL-O-10295 (ORD)

Keep the oil level at a point between "F" and "L" marks on the oil level gauge. Overfilling will cause improper lubrication; operation of the plant with the oil level below the "L" mark will result in engine failure.

Check the condition of the oil fill cap gasket periodically. It must be in good condition, and the oil fill cap must be securely tightened each time the cap is installed on the oil base. The engine crankcase operates under a slight vacuum, and air leakage thru the cap will cause loss of vacuum resulting in oil carry over at the breather or oil leakage at the seals.

The use of detergent crankcase oil helps to increase the life of the pistons and piston rings. If a non-detergent oil is used initially and a change is made to a detergent oil, allow only one third the usual operating hours between the next two oil changes. Thereafter change oil at the regular periods as recommended under Periodic Service.

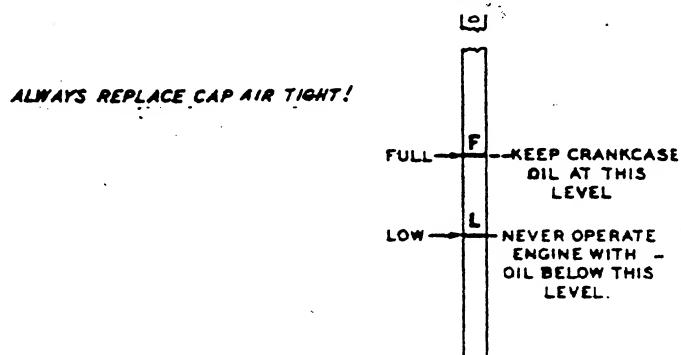


FIG. 4 - OIL LEVEL INDICATOR

Install the crankshaft key. Remove the clutch setscrew. Install the clutch assembly (less housing) to the crankshaft, driving it on carefully with a soft faced hammer until setscrew hole is aligned. Install setscrew to bottom in crankshaft hole then back it out one full turn. Tighten clutch retaining screws until clutch is clamped securely to crankshaft. Lock the screws. Then tighten the set screw.

With clutch housing top plate removed, smear grease over serrated power take-off shaft. Position the clutch throw out collar to align the grease fitting with the hole in the housing (#1 cylinder side, horizontal). Pull the throw-out collar outward to remove tension.

Install the clutch housing so that the clutch throw-out fork engages the throw-out collar. Be sure the serrated shaft is properly meshed with the clutch plate. Use two capscrews 7/16-14 x 2" on the lower and one capscrew 7/16-14 x 1-3/4" on the upper #2 cylinder side. Install the stud washers and nut. Lubricate the two grease fittings just until grease appears.

ADJUSTING THE ROCKFORD CLUTCH. - With the engine stopped, the clutch released (disengaged lever position), and the top plate removed from the clutch housing, use tools as illustrated to turn the adjusting ring (2) inward (clockwise facing power take-off shaft) until the toggles can not be locked over center. Locking screw (1) may remain tightened.

Then loosen the adjusting ring a notch or two at a time until the toggles can be locked over with a very firm pull on the engaging lever (3).

Start the engine and work the engaging lever back and forth several times, allowing the clutch to pick up load but not to lock over center. This is especially important with a new clutch plate as it knocks off high spots and fuzz.

Stop the engine and tighten the adjusting ring two or three notches for final adjustment. **IMPORTANT:** Be sure the toggles lock over center at final adjustment with a very firm pull on the engaging lever required to engage the clutch.

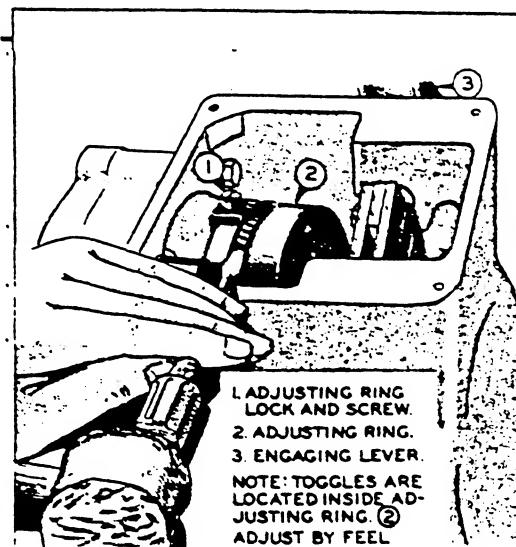


FIG. 3 - ROCKFORD CLUTCH ADJUSTMENTS

PRELIMINARY. - Before starting the engine make a final check to be sure all requirements under PREPARATION and under ABNORMAL OPERATING CONDITIONS have been complied with.

Open all valves in the fuel line.

The engine is run-in, tested and adjusted at the factory and normally does not require readjusting unless there is a major change in fuel or altitude.

STARTING THE ENGINE. - If the engine was not run recently to assure a sufficient supply of fuel in the carburetor, prime the fuel system by working the fuel pump priming lever, then leave the knob all-the-way inward to allow normal fuel pump operation.

Pull outward on the choke control, as required by temperature conditions. No choking is necessary when starting an engine which is warm from recent running.

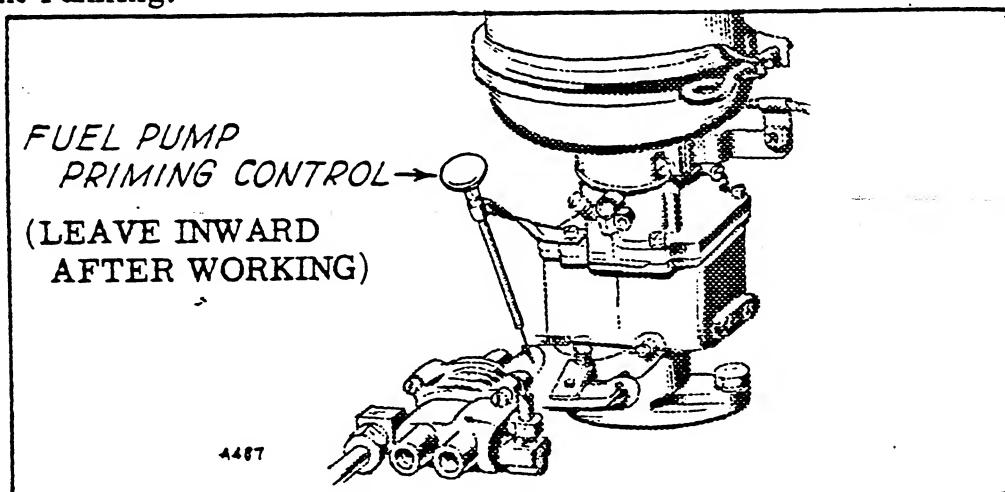


FIG. 6 - PRIMING THE FUEL SYSTEM

Insert the starting rope in a notch in the rope sheave and wind the rope in a clockwise direction around the sheave, leaving about six inches free at the handle end. Give a strong steady pull the full length of the rope to crank the engine. If the engine does not start at the first attempt, readjust the choke control for less choking and again crank the engine. Avoid overchoking. Overchoking causes oil dilution and excessive wear of internal parts.

Continued failure of the engine to start readily usually points to trouble in the fuel or ignition system.

If the engine is optionally equipped with a manual speed control, start, and allow the engine to warm up, at slow speed.

If the engine is optionally equipped with a Readi-Pull starter, the starting rope will recoil automatically.

GOVERNOR LINKAGE. - The ball joint on the governor linkage will function best and have extended life if it is lubricated only with powdered graphite. However, if graphite is not available, a light non-gummy lubricating oil should be applied.

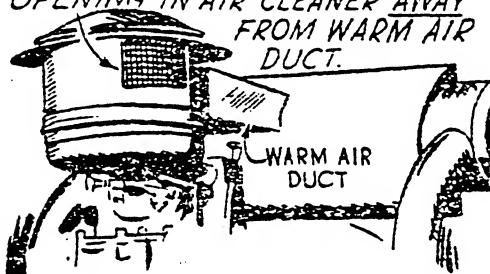
Place a drop of light oil on each joint of the carburetor throttle control joints.

SPARK PLUGS. - Preservative oil was sprayed into the cylinders before shipment. It may be necessary to remove the spark plugs, clean in gasoline, dry, and reinstall them before the engine will start the first time.

AIR CLEANER. - Service the air cleaner as instructed under Daily Service in the PERIODIC SERVICE section.

A special dry type air cleaner is used in conjunction with a carburetor air heater duct attached to the muffler. The top of the air cleaner is free to rotate when loosened, so that the opening may be brought into alignment with the heater duct. When the ambient temperature falls below 40°F. the opening should be in a position facing the duct so that air, heated by the muffler, will pass directly into the air cleaner. The opening must be rotated away from the duct when ambient temperatures are above 40°F.

WHEN OPERATING UNIT AT TEMPERATURES ABOVE 40°F. TURN OPENING IN AIR CLEANER AWAY FROM WARM AIR DUCT.



WHEN OPERATING UNIT AT TEMPERATURES BELOW 40°F TURN OPENING IN AIR CLEANER TOWARD THE WARM AIR DUCT.



FIG. 5 - AIR CLEANER HEAT DUCT

FUEL. - Fill the fuel tank nearly full with clean, fresh, regular gasoline. NEVER FILL THE FUEL TANK WITH THE ENGINE RUNNING AND DO NOT FILL THE TANK ENTIRELY FULL. The gasoline may expand and overflow, causing a fire hazard.

If practicable, avoid the use of gasoline having a high lead content. The use of such highly leaded gasoline will necessitate more frequent lead removal or valve grinding servicing.

LOW TEMPERATURES

CRANKCASE OIL. - Use caution in starting the engine after a shut-down in cold weather. Congealed oil may not flow readily, resulting in lack of lubrication to vital parts and causing serious damage. Do not attempt to start an engine which is so "stiff" that it is difficult to crank. In an emergency, apply heat directly to the oil base, using care as there is danger of cracking the oil base due to rapid expansion of the metal. When the oil is sufficiently fluid, start the engine and allow it to thoroughly warm up. Stop the unit and change the oil to the proper viscosity, as recommended under PREPARATION, for the expected temperature conditions.

Change oil every 50 operating hours when using oil lighter than OE #10 grade.

FUEL. - Give special attention to fuel. Use only fresh, clean, winter grade gasoline. Keep the fuel tank nearly full in order to reduce the condensation of moisture inside the fuel tank. Such moisture condensation can cause considerable trouble from ice formation in the fuel system. If the engine is moved from a warm location to a cold one, or from a cold location to a warm one, filling the fuel tank immediately before the move will reduce condensation to a minimum.

AIR CLEANER. - When operating in temperatures below 40°F., see that the air cleaner opening is turned toward the muffler heat duct as shown under PREPARATION.

HIGH TEMPERATURES

CRANKCASE OIL. - Use the correct grade of oil in the crankcase as indicated under PREPARATION. Keep the oil level at or near the upper level "F" mark on the level indicator. However, never over-fill the crankcase so that the oil level is above the "F" mark.

COOLING. - See that nothing obstructs the flow of cooling air to the engine. Be sure that all air housing parts are undamaged and are properly in place. Do not allow dust, dirt, leaves, straw, etc. to accumulate on cooling fins.

DUST AND DIRT

GENERAL CLEANING. - Keep the entire unit as clean as possible. Wipe off dust and dirt, never allowing deposits to accumulate. Use particular care to keep the engine cooling fins clean and free of obstructions to air flow.

If practicable, have the load disconnected during the starting and warm-up periods.

WARM-UP PERIOD. - Read the oil pressure gauge immediately after starting. The oil pressure should be between 20 and 35 pounds at normal operating temperature, but may be somewhat higher during the warm-up period. Stop the engine and investigate the cause if oil pressure is incorrect.

Readjust the choke control for smoothest operation until the engine warms up under load conditions and no choking is required.

Visually inspect the entire installation. Check for fuel leakage, loose connections, loose bolts, nuts or screws, misalignment of the engine and connected load, and anything else that might require attention.

STOPPING THE ENGINE. - Disconnect all load before stopping the engine, where practicable.

To stop the engine, push in firmly on the magneto STOP button, until the engine completely stops running.

In an emergency, such as failure of the STOP button to work, the engine may be stopped by shutting off the fuel supply. Another way, which may be used only in extreme cases, is to pull the choke control out to the limit of its travel.

The following recommended Engine Service Chart may be used as a guide for servicing ONAN Gasoline Engines.

The chart is based on favorable operating conditions.

SERVICE & PARTS REQUIRED	HOURS OF OPERATION																			COMPLETE RECONDITIONING 5000
	100	200	300	400	500	600	700	800	900	1000	1500	2000	2500	3000	3500	4000	4500	5000		
Oil Change (check level daily)...	x	x	x	x	x	x	x	x	x	x										
Clean & adjust Spark Plugs ...	x	x	x	x	x	x	x	x	x	x										
*Service Air Cleaner	x	x	x	x	x	x	x	x	x	x										
Check Ignition Points		x	x	x	x	x	x	x	x	x										
†Clean Carbon & Lead Deposits.			x					x	x	x	x	x	x	x	x	x	x	x	x	
Clean Carburetor									x	x	x	x	x	x	x	x	x	x	x	
Check Tappets				x					x	x	x	x	x	x	x	x	x	x	x	
Grind Valves									x	x	x	x	x	x	x	x	x	x	x	
Remove & clean Oil Base								x	x	x	x	x	x	x	x	x	x	x	x	
Clean Crankcase Breather	x	x	x	x	x	x	x	x	x	x										
Clean Engine								x	x	x	x	x	x	x	x	x	x	x	x	
Replace Spark Plugs											As Required									
Replace Valves											As Required									
Replace Points											As Required									
Replace Piston Rings											As Required									

If it is necessary to remove parts for inspection and gaskets are disturbed they should be replaced with new ones.

Periodic Inspection: For Loose or Poor Connections, Fittings, etc.

Recommended Oil: Heavy Duty Detergent or its Equivalent. Use the proper SAE number oil for the lowest temperature at the engine as expected at the time of starting.

NOTE * - Check the air cleaner often. Thoroughly clean and put in fresh oil at least every 100 hours. Install a heavy duty air cleaner if necessary.

NOTE † - Recommended fuel: Use "Regular" Automotive Gasoline - Do not use "Premium" Type Gasoline. If a high lead content fuel is used, it will be necessary to remove the lead deposits more frequently.

Keep Engine clean.

AIR CLEANER. - Service the air cleaner as frequently as conditions require. Do not allow the air cleaner to become so laden with dirt as to restrict the air flow to the carburetor.

FUEL AND OIL SUPPLIES. - Keep reserve supplies of fuel and oil in air tight containers to prevent contamination with air borne dust and dirt.

HIGH ALTITUDE

If the unit is to be operated at an altitude of 2500 feet or more above sea level, the carburetor main jet adjustment should be "leaned" slightly to obtain maximum possible power. The carburetor was adjusted for best performance at the factory altitude: approximately 860 feet. Because the air becomes less dense as the altitude increases, less fuel is required to maintain the proper air-to-fuel ratio. Consequently, any engine will develop less power at higher altitudes. The usual altitude de-rating amount is approximately 4 per cent for each 1000 feet above sea level.

ways drain the oil only when the engine is warm from recent running.

If the engine has been operating under LOW TEMPERATURE conditions using oil lighter than OE #10 grade, or if highly leaded fuel were used, then change the crankcase oil every 50 operating hours.

If the engine was optionally equipped with a permanent cartridge type oil filter, remove the drain plug at the bottom of the filter to drain the sludge from the oil filter each time the crankcase oil is changed. Replace the drain plug securely.

SPARK PLUGS. - Remove the spark plugs, clean them, and adjust the gap to 0.025 inch. Replace with a new one any plug which does not pass a standard firing test. **CAUTION:** Use only a suitable wrench on the hex section of the spark plug to avoid damage to the plug suppression quality.

GOVERNOR LINKAGE. - Lubricate the governor arm with a dry type lubricant such as powdered graphite to assure best performance and longest life of the ball joint. If graphite is not available, use a light non-gummy oil.

Place a drop or two of oil at the point where the governor linkage engages the carburetor throttle arm.

200 HOUR SERVICE

Perform the following services every 200 hours of operation.

IGNITION POINTS. - Remove the magneto end cover and inspect the breaker points. Slight burning or pitting can be corrected by removing the points and resurfacing them smooth on a fine abrasive stone. If the points are badly burned or pitted, replace them with a new set. Frequent burning, or pitting of one contact with a corresponding high point on the other contact, is an indication of a defective capacitor.

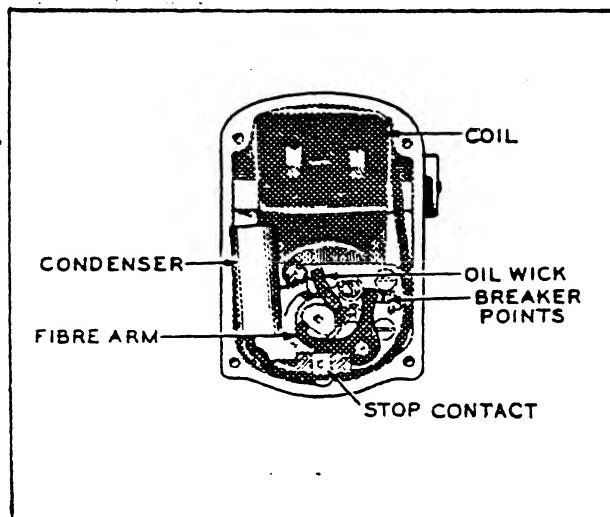


FIG. 7 - BREAKER POINTS

Adjust the point gap to 0.020 inch at full separation. Always keep the points clean and free of any oil. When a new point set is installed, be sure to lubricate the pivot pin by wiping with the new wick provided. Be sure to install the new wick, also.

The efficiency of the engine depends a great deal on the care and attention given it. By following a definite schedule of inspection and service the operator can avoid engine failures caused by neglect. Service periods are based on hours of running time and are for normal operating conditions. For extreme conditions of load, dust, dirt, etc., service more often.

DAILY SERVICE

Perform the following services daily or at the end of each 8 hours of running time, whichever occurs first.

LUBRICATION. - Check the crankcase oil level. Be sure the engine is setting level to avoid a false reading. If necessary, add proper oil to bring the crankcase oil level to the full mark on the gauge. Never allow the engine to run when the oil level is below the low mark on the gauge. Do not overfill the crankcase as the connecting rods may strike the oil, cause it to foam, and interfere with proper lubrication. Always be sure the oil filler cap is securely tightened. Air leaking into the crankcase at this point may cause oil carry over at the breather or leakage at the seals.

If the engine is optionally equipped with a permanent cartridge type of oil filter, keep the cartridge clean by turning the handle one complete turn in a clockwise direction.

FUEL. - Check the fuel supply. The amount of fuel used will vary due to load conditions, operating conditions, etc. Fill the fuel tank as often as necessary to assure a continuous supply of fuel. Stop the engine when refilling the tank unless the tank is a safe distance from the engine. Use good fresh regular grade of gasoline. DO NOT USE PREMIUM GRADE GASOLINE unless regular grade is not available.

AIR CLEANER. - Service the air cleaner as required by the operating conditions. Under extremely dusty conditions, it may be necessary to clean the air cleaner several times a day. Under dust-free conditions, a weekly inspection may be sufficient.

GENERAL. - Keep the cooling surfaces of the engine clean and free of dust, dirt, and grease. Wipe off any spilled oil from engine surfaces. Keep oily rags in metal containers or destroy them to limit fire hazards.

50 HOUR SERVICE

Perform the following services every 50 hours of operation.

CRANKCASE OIL. - Under normal operating conditions, change the crankcase oil every 100 hours of operation. Al-

500 HOUR SERVICE

Perform the following services every 500 hours of operation.

CARBON AND LEAD REMOVAL. - The frequency of necessary carbon or lead deposits removal will vary with operating conditions and with the type of fuel used. The use of highly leaded gasoline causes a more rapid accumulation of lead deposits in the combustion chambers. Remove carbon or lead deposits as experience indicates the necessity. After removing the cylinder heads, scrape all carbon or lead deposits from the cylinder heads, ends of piston, and valves. Inspect the valves carefully, perform a valve grind operation if indicated. After installing the cylinder heads, be sure to replace the cylinder air covers properly.

VALVE GRINDING. - The proper seating of the engine valves is essential to good engine performance. The valves are fitted with rotators which keep the valves turning during operation. This turning action lengthens the time interval between necessary valve grinding operations considerably. If examination during carbon cleaning or other tests indicate that any one valve is leaking, service all four valves at the same time.

ENGINE COMPRESSION. - If engine power is low, loss of compression is a likely cause. A new engine will show a compression reading of approximately 90 pounds at sea level when rapidly hand cranked. If the reading is as low as 65 pounds, or if there is a difference of more than 10 pounds between cylinders, repair as necessary.

VALVE TAPPETS. - Remove the valve compartment covers and check the tappet clearances. Adjust as necessary to obtain 0.006 to 0.008 inch clearance for both the intake and exhaust valves.

CRANKCASE BREATHER VALVE. - Release the clamp from the top of the crankcase breather tube. Tip the breather cap up and remove the flapper valve from the cap. Clean the valve thoroughly with gasoline or other solvent. Replace the valve with a new one if the flapper diaphragm is worn or damaged so as to prevent proper seating to the perforated disc. Install the valve, making sure it seats properly in the cap and is diaphragm side up. Tighten the cap firmly in place on the breather tube.

The breather valve helps to maintain a slight vacuum in the engine crankcase while the engine is running. If the flapper valve is not working properly, or if there is an air leak at the cap, the vacuum may be destroyed and excessive oil consumption or oil leakage may result.

CAUTION: - When installing the breather valve, BE SURE THE PERFORATED DISC FACES DOWNWARD, WITH THE DIAPHRAGM UPWARD. If the valve is installed in reversed position, loss of the crankcase oil may result. See that the cap is properly installed so that there is no leak at this point.

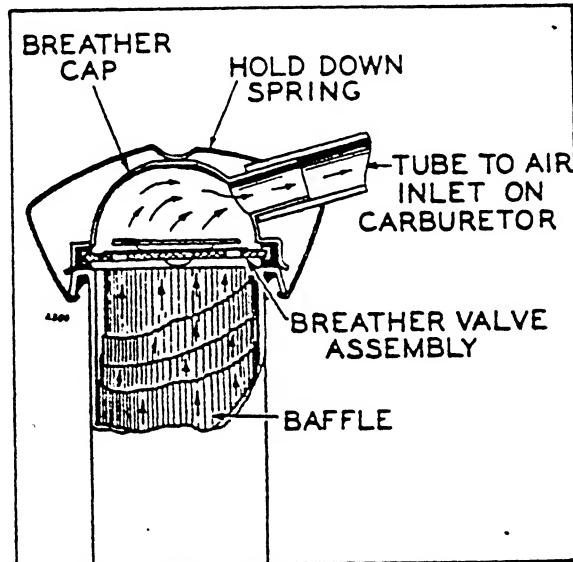


FIG. 8 - BREATHER VALVE

FUEL SYSTEM. - If a fuel filter is used in the fuel system, shut off the fuel and thoroughly clean the sediment bowl and screen. Install a new bowl gasket if necessary. Reassemble the filter, turn on the fuel, and operate the fuel pump to prime the system. Inspect for leaks and correct any found.

EXHAUST. - Inspect the exhaust system for leaks. Tighten or replace all parts needing it.

GENERAL INSPECTION. - Thoroughly inspect the entire unit for oil leaks, worn parts or loose bolts or nuts. Make any necessary repairs.

Adjust the main adjusting needle with a full load connected. Turn the main adjusting needle slowly in until the speed and power begin to drop. Turn the adjusting needle out slowly to the point where the highest speed is reached, then turn 1/4 turn farther out for the final setting.

Adjust the idle needle with all load disconnected, and with the idle control (where used) pulled out to idle the engine. Turn the idle adjusting needle out slowly until the engine starts to run unevenly, then turn in to the point where engine speed is at its highest point and operation is steady.

If a hunting condition (alternate increase and decrease of speed) can not be corrected by a richer air-fuel mixture, it may be necessary to readjust the governor sensitivity. A major change in a carburetor adjustment will necessitate a readjustment of the governor.

If the engine runs rough, probably the fuel level in the carburetor is too high due to an incorrect float setting or a leaking fuel inlet needle valve. The fuel level should be just below the float bowl inspection hole. To reset the float level, remove the upper body assembly containing the complete float mechanism. It is necessary to first carefully remove the idle screw, spring and internal tube. Turn the assembly upside down and with the float lever resting on the inlet needle, carefully bend EACH lever arm, if necessary, to give a distance of 1-29/64 inches from the face of the body gasket to the then top of raised seam encircling each float. If the engine is low on power, probably the fuel level is too low.

GOVERNOR ADJUSTMENT. - The governor is set at the factory to allow a nominal engine speed of 2400 rpm at no load operation, unless another speed is specified when the engine is ordered. Maximum rated speed is 3600 rpm at full load.

Proper governor adjustment is one of the most important factors in maintaining the power and speed desired from the engine.

Carefully study the related subjects in the following paragraphs and check each point in the order given before attempting adjustments on the governor:

1. GENERAL. - Before making governor adjustment, run the engine about 15 minutes to reach normal operating temperature.

If the engine is being run with the throttle wide open, either the governor is not properly adjusted or the engine is overloaded.

It is difficult to determine if after long usage the governor spring has become fatigued. If after properly making all other adjustments the regulation is still erratic, install a new spring.

GENERAL. - Satisfactory engine performance is largely dependent upon correct adjustments. However, adjustments can not fully compensate for low engine power due to wear, etc. If trouble develops, follow an orderly procedure to determine the cause before making any adjustment. Refer to the SERVICE DIAGNOSIS section for help in checking causes of troubles which may occur.

CARBURETOR. - The carburetor has "main" and "idle" adjusting needle valves, as illustrated. The main adjusting needle setting determines the air-fuel mixture ratio under all load conditions, and affects the operation at the heavier load conditions. The idle adjusting needle affects the operation at light load or idle conditions, but does not alter the air-fuel mixture ratio established by the main adjustment. Be sure the air cleaner is not restricted so as to choke the engine.

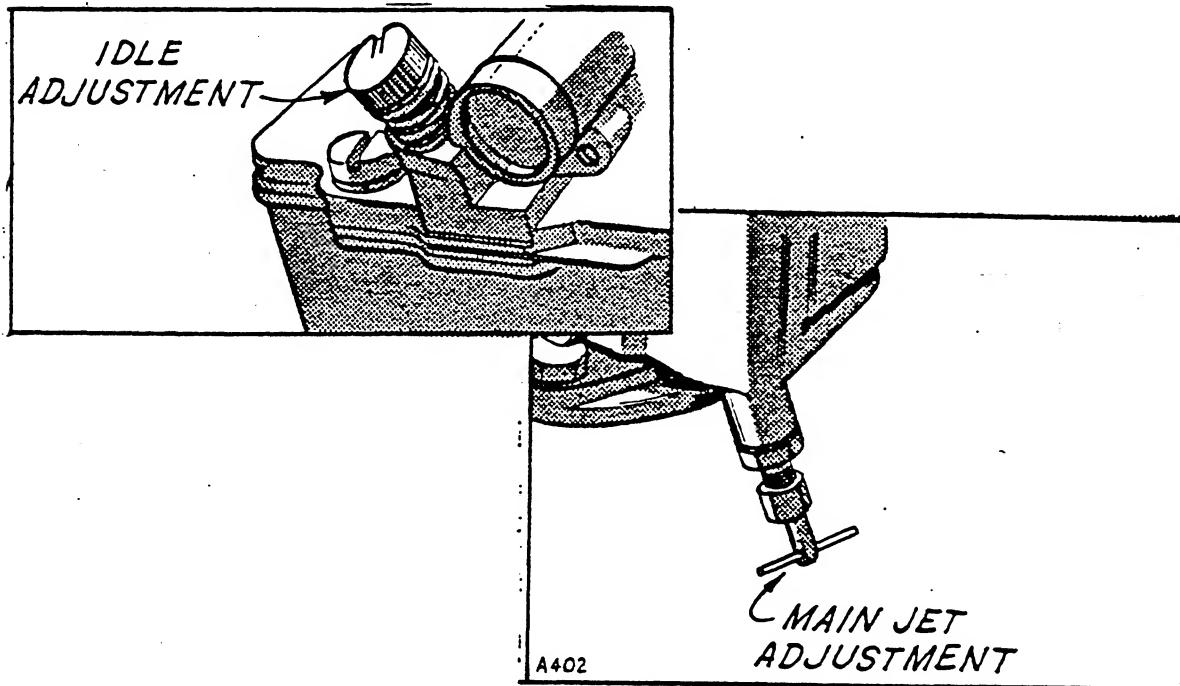


FIG. 9 - CARBURETOR ADJUSTMENTS

Under normal circumstances, the factory carburetor adjustments should not be disturbed. If the carburetor has been disassembled for cleaning, or the adjustments otherwise changed, an approximate setting of 2-1/2 turns open for the main adjustment and 3/4 turn open for the idle adjustment will permit starting the unit. Allow the engine to thoroughly warm up before attempting to make final adjustments.

CAUTION: -Never turn the adjusting needles tightly in to their seats.. Doing so may form a ridge or ring on the tapered end, which will make proper adjustment impossible.

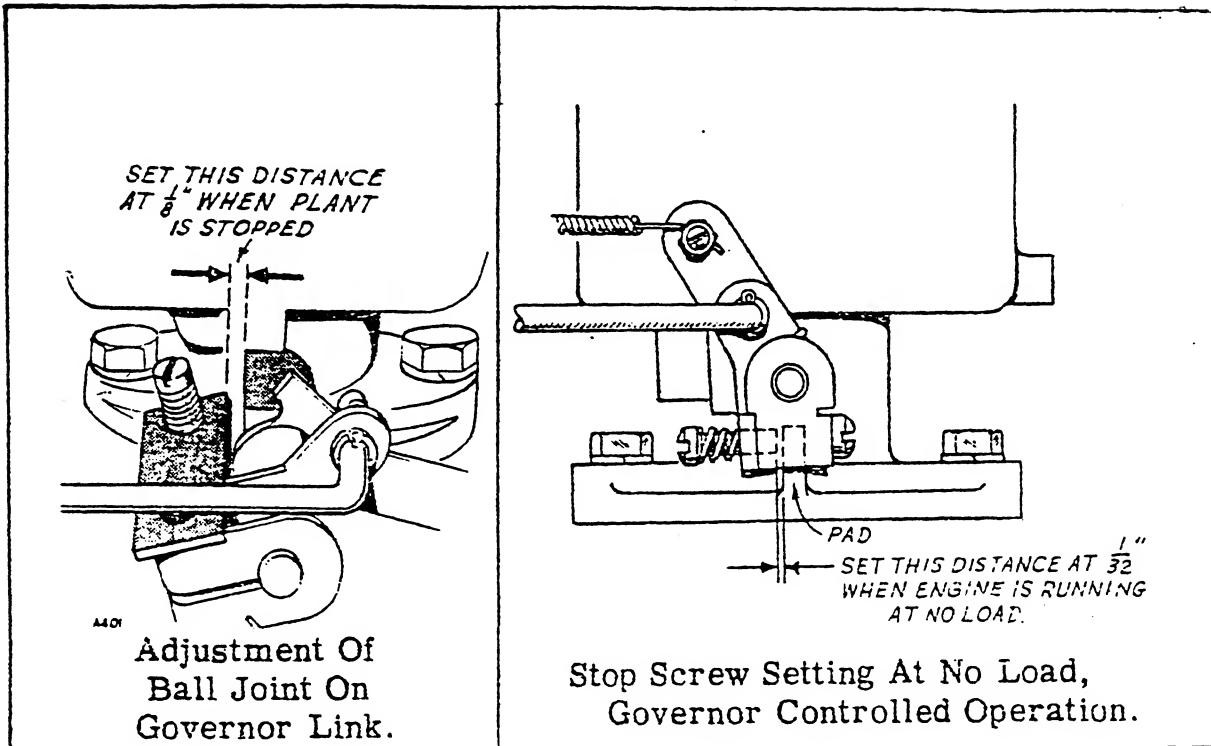


FIG. 10 - THROTTLE STOP LEVER POSITION

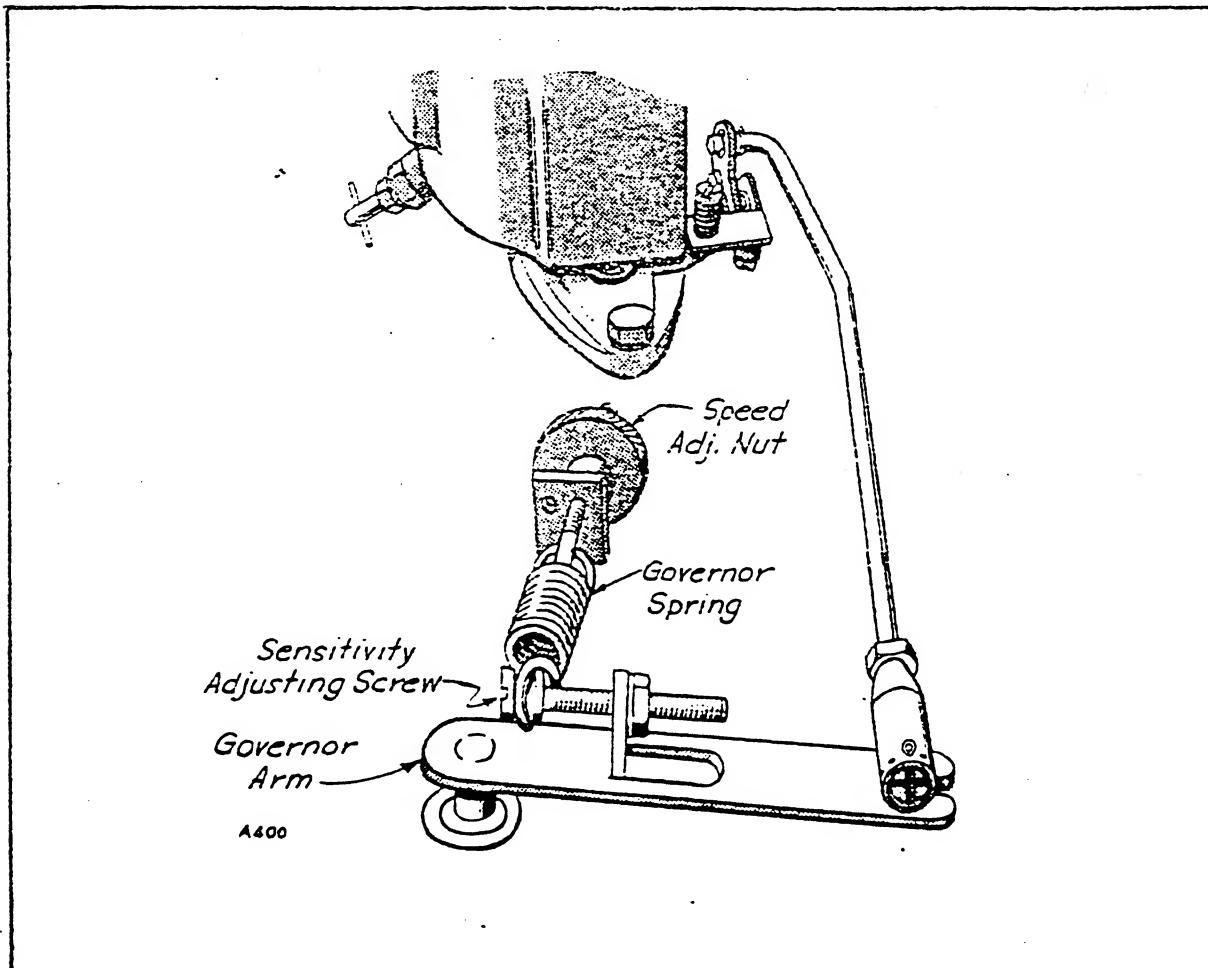


FIG. 11 - GOVERNOR ADJUSTMENTS

A reliable instrument for checking engine speed is required for accurate governor adjustment. Engine speed can be checked with a tachometer.

Check the governor arm and linkage and the throttle shaft and lever for a binding condition and for excessive slack or wear at connecting points. A binding condition at any point will cause the governor to act slowly and regulation will be poor. Excessive looseness will cause a hunting condition and regulation will be erratic. Work the arm back and forth several times by hand while the engine is stopped. If either of these conditions exist, find out where the trouble lies and adjust or replace parts as needed.

2. STEPS TO FOLLOW. - This gives the procedure only briefly. Refer to the details on each subject herein.

- a. Adjust the carburetor main jet for the best fuel mixture at full load operation.
- b. Adjust the carburetor idle needle with no load connected.
- c. Adjust the length of the governor linkage.
- d. Check the governor linkage and throttle shaft for binding or excessive looseness.
- e. Adjust the governor spring tension for nominal engine speed at no load operation.
- f. Check the rpm drop between no load and full load operation and adjust the governor sensitivity as needed.
- g. Recheck the speed adjustment.
- h. Set the carburetor throttle stop screw.

3. LINKAGE. - The engine starts at wide open throttle. The length of the linkage connecting the governor arm to the throttle shaft and lever is adjusted by rotating the ball joint. Adjust this length so that with the engine stopped and tension on the governor spring, the stop on the carburetor throttle shaft is $1/8$ inch from the stop pad of the carburetor body. This setting allows immediate control by the governor after starting. It also synchronizes the travel of the governor arm and the throttle shaft. Hold the nut and turn the ball to avoid damage to the lock washer when removing the joint from the governor arm.

4. SPEED ADJUSTMENT. - The speed at which the engine operates is determined by the tension applied to the governor spring. Increasing spring tension increases engine speed. Decreasing spring tension decreases engine speed. The no-load speed of the engine should be slightly higher than the speed requirements of the connected load. For example: If the connected load is to turn at 2310 rpm, set the no-load speed of the engine at about 2400 rpm. Check speed with a tachometer.

If a speed adjustment is needed, turn the speed adjusting nut in to increase the speed or out to decrease the speed. See the illustration, Governor Adjustments. Be sure the knife edges of the nut fit into the groove in the governor spring bracket.

5. SENSITIVITY ADJUSTMENT. - Refer to the illustration, Governor Adjustments. The engine speed drop from no load to full load must be within 100 rpm. Check the engine speed with no load connected and again after connecting a full rated load.

To increase sensitivity (reduce rpm drop between no load and full load) move the speed spring nearer to the governor shaft by turning the sensitivity adjusting screw outward. An adjustment too close will cause hunting (alternate increase and decrease of engine speed). A fuel mixture too lean will also cause a hunting condition.

To decrease sensitivity move the speed spring away from the governor shaft by turning the sensitivity screw inward.

The correct position of the sensitivity stud will give the closest regulation without any hunting condition.

Always recheck the speed adjustment after a sensitivity adjustment. Increasing sensitivity will cause a slight decrease in speed and will require a slight increase in the governor spring tension.

6. THROTTLE STOP SCREW. - The throttle lever stop screw should be set at 1/32 inch distance from the carburetor bowl when the engine is operating with no load connected.

OIL PRESSURE RELIEF VALVE. - The oil pressure of the engine is adjustable by means of the slotted stud and locknut located below the governor linkage. Oil pressure of a warmed-up engine is 20 to 35 pounds. To increase oil pressure, loosen the lock nut and turn the stud in. Turn the stud out to decrease. Tighten the locknut securely after making an adjustment. Low oil pressure may point to too much clearance between bearings and their journals, a weak or broken by-pass spring, a defective gauge, or a poor adjustment.

To clean the valve or replace the spring, loosen locknut and remove the stud and nut.

TIMING THE IGNITION. - It should not be necessary to retime the ignition unless the magneto has been removed or shifted from the factory setting. Always be sure the magneto breaker points are properly gapped, as instructed under PERIODIC SERVICE, before checking the timing.

The magneto ignition timing is set at 11° spark advance for starting. The spark is automatically advanced to 26° for running, through the impulse coupling of the magneto.

Read all of the instructions first. If the magneto must be reinstalled, remove the blower housing to make the timing marks more visible then follow these steps:

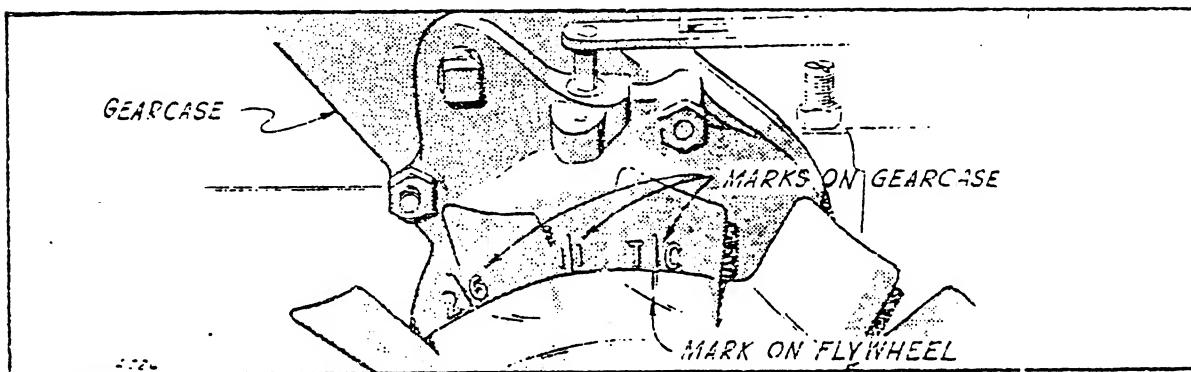


FIG. 12 - IGNITION TIMING

1. Rotate the flywheel until the witness mark is $1/4$ revolution, or 90° , to the left of the "TC" mark on the gear cover (or in line with #1 cylinder).
2. Hold the magneto in the same position it will occupy in the bracket.
3. Turn the magneto gear counterclockwise until it stops turning freely.
4. Start the magneto into the magneto bracket. Before the magneto gear meshes with the idler gear, look thru the adjusting slot on the bracket and see that the magneto mounting hole is so located that the mounting screw can travel about the same distance in either direction in the slot.
5. Tighten the mounting screws to hold the magneto in the position described in step 4.
6. Rotate the flywheel slowly in a clockwise direction until the impulse coupling makes a distinct, loud click. The witness mark should now be lined up with the 11° mark on the gear cover.

GENERAL. - Most standard automotive engine procedures will apply for major engine repairs.

ASSEMBLY TORQUES. - If a torque wrench is not available, estimate the tightness. Do not strip threads.

CYLINDER HEAD NUTS	24-26 Lb. Ft. (cold)
REAR BEARING PLATE NUTS	20-25 Lb. Ft.
OTHER 5/16" NUTS	10-12 Lb. Ft.
CONNECTING ROD BOLTS	27-29 Lb. Ft.
FLYWHEEL MTG. BOLT	35-40 Lb. Ft.
OIL BASE NUTS	30-35 Lb. Ft.

TABLE OF CLEARANCES. - The clearances given are the factory standards at 70°F. A comparison between the standard clearances shown, and clearances as determined during repair operations will usually indicate which parts should be replaced with new. As a general rule, when the clearance exceeds by 50% the upper factory limit (or nearly so), the worn parts should be replaced with new ones. For example, if connecting rod bearing clearance (factory clearance 0.0005 to 0.002 inch) is 0.003 inch or more, new bearings should be installed. For those clearances which are adjustable (tappets, etc.) keep the clearances within the factory tolerance.

TABLE OF CLEARANCES (IN INCHES)

	MINIMUM	MAXIMUM
Tappets (Intake and Exhaust)	0.006	0.008
Valve stem in guide-intake	0.001	0.0025
Valve stem in guide - exhaust	0.0025	0.004
Valve seat angle	45°	
Valve face angle	44°	
Valve interference angle	10	
Valve seat width	3/64	5/64
Main bearing	0.002	0.003
Crankshaft endplay	0.006	0.012
Camshaft bearing	0.0015	0.003
Connecting rod bearing	0.0005	0.002
Connecting rod endplay	0.012	0.032
Timing gear backlash	0.002	0.003
Oil Pump gear backlash	0.002	0.005
Idler gear backlash	0.002	0.005
Piston to cylinder (skirt, 90° to pin)	0.0025	0.0045
Piston pin to piston	Thumb push	
Piston pin to rod	0.0001	0.0006
Piston ring gap	0.010	0.023
Magneto breaker point gap	0.020	
Spark plug gap	0.025	
Ignition timing - retarded (engine stopped)	11° BTC	
Ignition timing (engine running)	26° BTC	
Cylinder bore, standard size	2.9985	2.9995
Crankshaft main bearing journal, std. size	1.9995	2.000

7. If the flywheel witness mark is past the 11° mark when the magneto click is heard, loosen the magneto mounting screws and turn the magneto slightly in the direction of flywheel rotation to advance the spark.
8. If the flywheel witness mark has not reached the 11° mark when the click is heard, turn the magneto slightly opposite flywheel rotation to retard the spark. Recheck as necessary. Tighten the mounting screws and repeat Steps 1 and 6.
9. If the click is heard when the witness mark is a relatively great distance away from the 11° mark on the gear cover, the magneto gear must be disengaged from the idler gear and moved one tooth to the right or left to compensate for too early or too late firing of the impulse coupling. It is then necessary to repeat Steps 1, 2, 3, 4, 5, 6, 7 and 8.

GASKETS. - Always use new gaskets when replacing any part that requires a gasket. Thoroughly clean the surface that the gasket contacts before installing the gasket.

POSSIBLE CAUSE

REMEDY

ENGINE MISFIRES AT LIGHT LOAD (Cont.)

Intake air leak.	Tighten or replace gaskets.
Faulty ignition.	Service ignition.
Poor compression.	Tighten cylinder heads and spark plugs. Repair engine.

ENGINE MISFIRES AT HEAVY LOAD

Defective spark plug or cable.	Replace.
Faulty ignition.	Service ignitions system.
Clogged carburetor or fuel system.	Clean.

ENGINE MISFIRES AT ALL SPEEDS

Fouled spark plug.	Clean and adjust or replace with correct plug.
Sticking valves.	Grind, or replace.
Broken valve spring.	Replace.
Defective ignition wires.	Replace.
Defective or improperly adjusted points.	Adjust or replace breaker points

LOW OIL PRESSURE

Oil too light or diluted from leaking pump diaphragm.	Drain, refill with proper oil. Repair or replace fuel pump.
Oil level too low.	Add oil.
Oil relief valve not seating.	Remove and clean, or replace.
Badly worn engine.	Overhaul.
Badly worn oil pump.	Replace.
Sludge on oil screen	Remove and clean.
Defective oil pressure gauge.	Replace.

POSSIBLE CAUSE	REMEDY
ENGINE CRANKS TOO STIFFLY	
Congealed lubricating oil.	Change to recommended oil.
Engine stuck.	Disassemble and repair.
ENGINE WILL NOT START WHEN CRANKED	
No fuel.	Replenish.
Fuel system restricted.	Open.
Cylinders flooded.	Crank with plugs removed.
Faulty ignition.	Service spark plugs and breaker points. Retime if necessary.
Poor compression.	Repair engine.
POWER DROPS UNDER HEAVY LOAD	
Engine lacks power.	See remedies for engine missing under heavy load.
Poor compression.	Tighten cylinder heads and spark plugs. If still not corrected, repair engine.
Faulty carburetion.	Check fuel system. Open choke. Clean air cleaner. Adjust air-fuel mixture for optimum setting.
Carbon in cylinders or in carburetor venturi.	Remove carbon.
Restricted exhaust line.	Clean or increase the size.
Governor not properly adjusted.	Adjust governor.
Fuel level in carburetor too low.	Adjust float.
ENGINE MISFIRES AT LIGHT LOAD	
Carburetor adjusted wrong or dirty.	Adjust, clean if needed.
Spark plug gap too narrow.	Adjust.

POSSIBLE CAUSE	REMEDY
LIGHT POUNDING KNOCK	
Loose connecting rod.	Replace bearing.
Low oil supply.	Add oil.
Low oil pressure.	See Low Oil Pressure for remedies.
ENGINE STOPS UNEXPECTEDLY	
Fuel tank empty.	Refill. Open valve.
Defective ignition.	Check and service ignition system.
DULL METALLIC THUD, IF NOT BAD MAY DISAPPEAR AFTER FEW MINUTES OPERATION. IF BAD, INCREASES WITH LOAD	
Loose crankshaft bearing.	Replace, unless one of the next two remedies permanently corrects the trouble.
SHARP METALLIC THUD, ESPECIALLY WHEN COLD ENGINE FIRST STARTED	
Low oil supply.	Add oil. Change if necessary.
Oil badly diluted.	Drain. Refill with proper oil.
PINGING SOUND WHEN ENGINE IS SUDDENLY OR HEAVILY LOADED	
Spark advanced too far.	Reset breaker points or retime ignition.
Wrong spark plugs.	Install correct spark plugs.
Spark plugs burned or carboned.	Clean, install new plugs if necessary.
Valves hot.	Adjust tappet clearance.
Fuel stale or low octane.	Use good, fresh fuel.
Lean fuel mixture.	Clean and adjust carburetor.
Carbon and lead in combustion chamber.	Disassemble engine and remove carbon or lead deposits.

POSSIBLE CAUSE

REMEDY

HIGH OIL PRESSURE

Oil too heavy. Drain, refill with proper oil.

Clogged oil passage. Clean all lines and passages.

Oil relief valve stuck. Remove and clean.

Defective oil pressure gauge. Replace.

ENGINE BACKFIRES AT CARBURETOR

Lean fuel mixture. Clean or adjust carburetor.

Clogged fuel screen. Clean screen (where used).

Air leaks at intake manifold. Replace gaskets, tighten.

Poor fuel. Refill with good, fresh fuel.

Spark too early. Regap points & retime if necessary.

Intake valve leaking. Reseat or replace.

EXCESSIVE OIL CONSUMPTION, LIGHT BLUE SMOKY EXHAUST

Poor compression, worn engine. Repair engine.

Too large bearing clearance. Replace bearings if necessary.

Oil too light or diluted. Drain, refill with correct oil.

Too much oil. Drain excess oil.

Air leak at oil fill cap. See that cap fits tightly and that gasket is not damaged.

Crankcase breather valve sticking. Clean. Replace if necessary.

EXCESSIVE FUEL CONSUMPTION, BLACK SMOKY EXHAUST

Fuel mixture too rich. See that choke opens properly. Adjust jets properly.

Dirty air cleaner. Clean.

POSSIBLE CAUSE

REMEDY

TAPPING SOUND

Valve clearance too great. Adjust to proper clearance.

Broken valve spring. Install new spring.

HOLLOW CLICKING SOUND WITH COOL ENGINE UNDER LOAD

Loose piston. If noise is only slight and disappears when engine warms up no immediate attention needed. Otherwise replace parts necessary.

